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Stakeholder perceptions of scientific knowledge in policy processes: A Peruvian case-study of forestry policy development

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Abstract

There is a need to better understand how scientific knowledge is used in decision-making. This is especially true in the Global South where policy processes often occur under high political uncertainty and where a shift toward multilevel governance and decision-making brings new opportunities and challenges. This study applies knowledge-policy models to analyse a forestry research project that succeeded in influencing national policy-making. We investigate how decisions were made, what factors affected and shaped the policy process, and how scientific knowledge was used. The results highlight the complexity of policy processes and the related challenges in crossing the science-policy interface. Perceptions of scientific knowledge differed greatly among stakeholders, and those perceptions strongly influenced how scientific knowledge was valued and used. The findings suggest a need for researchers to better understand the problem context to help design and implement research that will more effectively inform decision-making.

Key words: science-policy interface, knowledge-policy models, reseach influence in decision-making, stakeholders perceptions of research

1. Introduction

With high contemporary interest in the social impacts of research (Holbrook 2010; Bell *et al.* 2011; Bozeman and Sarewitz 2011; Bornman 2012; Enquist *et al.* 2017) and in the promotion of evidence-informed policy (Likens 2010; Saltelli and Giampietro 2017), there is a clear need for better understanding about whether and how research and research-based evidence contributes to policy discourse and policy formation.

There is a growing body of literature on the relationship between scientific research and policy-making (Jones 2009; Jones *et al.* 2009; Valente *et al.* 2015; Cáceres *et al.* 2016; Rose *et al.* 2017), or what other authors refer to as the science-policy interface (Pielke 2007; Weichselgartner and Kasperson 2010; Armitage *et al.* 2015). Theoretical and empirical work in fields such as Science, Technology, and Society (STS) and political science that focus explicitly on policy processes, as well as in individual scientific disciplines (e.g., Jones 2009; Valente *et al.* 2015; Enquist *et al.* 2017), explore the links between research and policy. Yet, despite the development of theories, models, and empirical work on the topic, ongoing deficiencies in science–policy interactions suggest that there is still a need to better understand the links and factors underpinning the science–policy interface (Jones 2009; Weichselgartner and Kasperson 2010; Valente *et al.* 2015; Siyanbola *et al.* 2016).

Fewer studies have focused on the Global South, where political uncertainty increases the challenge of understanding how scientific knowledge is used in policy-making (Jones *et al.* 2008; Jones 2009; Siyanbola *et al.* 2016). Furthermore, general global trends in public participation and decentralization, especially in developing countries, are part of an evolution from government-centered technocratic policy-making towards multi-actor participation in decision-making (Ribot and Larson 2005; Armitage *et al.* 2012) with implications for the exchange, validation, and uptake of knowledge in environmental policy (Jones *et al.* 2012, Armitage *et al.* 2015; Valente *et al.* 2015). Decentralization provides mechanisms to facilitate the use of local knowledge in decision-making and increase legitimacy and equity (Ribot and Larson 2005). Processes of decentralization and democratization started around the mid-20th century and gained momentum in developing countries in the 1980s and 1990s, driving processes of governance and participation in decision-making (Ribot and Larson 2005; Jones *et al.* 2009). The formalization and effective implementation of decentralization and democratization to foster stakeholder participation in policy processes have been highly variable across countries (Jones *et al.* 2009). While in some contexts there are official mechanisms for stakeholder involvement in policy processes, in other contexts, non-state actors' participation is still elusive and dependent on the government in place (Jones *et al.*

2009). Despite the proliferation of scientific research on sustainability topics, the actual use and influence of scientific knowledge in sustainability decision-making has been limited (van Kerkhoff and Lebel 2006). If we are to design and implement research that will be useful and used in policy discourse and which will effectively provide evidence that informs and influences policy formation and implementation, we need to understand and take account of how decisions are made, the factors that affect and shape the policy process, as well as specifically how research-based knowledge is used and how can it be made more useful.

This article contributes an empirical analysis of a case study from the Global South about how scientific evidence informed a policy process. The case study analyses the outcomes of a research project on the impact of timber harvesting on Brazil nut productivity in the Peruvian Amazon. As a result of the project, the research findings informed the development of regulations on the management of Brazil nut concessions in a new forestry policy for Peru. This direct link between research and policy was characterized by some informants as unprecedented in the country, at least in the forest sector.

This case study provides an ideal opportunity to examine how knowledge availability and stakeholders' scientific literacy can influence scientific knowledge uptake and use in decision-making in a context of decentralization and increased public participation. The article examines knowledge utilization in the policy process, with a focus on the implications of stakeholder engagement and perceptions in the use of research-based knowledge. It aims to better understand how scientific knowledge contributes to policy development and how stakeholder engagement influences policy-making and the uptake of research findings. We ask three inter-related research questions: 1. How is scientific knowledge perceived by stakeholders?; 2. How do stakeholders' perceptions influence the policy process?; and 3. How is scientific knowledge used in decision-making in a policy process?

We use knowledge-policy models as analytical lenses to explore the relationship between the production of scientific knowledge and its use in policy formulation and implementation. These knowledge-policy models are useful to examine key factors and stakeholders' motivations influencing whether scientific knowledge or other kinds of knowledge are used to inform forestry policy processes in Peru, and provide insights about key aspects that should be taken into account when designing and conducting research aiming to influence policy in multilevel governance contexts such as Peru (Kowler *et al.* 2016). The models help characterize different moments and shifts in the policy process, particularly how different types of knowledge are used and the motivations for its use.

We use the concepts of credibility, relevance, and legitimacy (Cash *et al.* 2003; Heink *et al.* 2015) to characterize stakeholders' perceptions of scientific knowledge. Stakeholders' motivations are determined by their worldviews and interests, which also shape their perceptions about the usefulness and reliability of knowledge. Relevance, credibility, and legitimacy are useful concepts to characterize and reflect on the research process and to frame and analyse stakeholder perceptions on research (Ramirez and Belcher, *in press*). These attributes have been identified as good predictors of the effectiveness at the science–policy interface. Belcher *et al.* (2016) define these concepts as:

- Relevance is the importance, significance, and usefulness of the research project's objectives, process, and findings to the problem context and to society.
- Credibility refers to whether or not the research findings are robust and the knowledge produced is scientifically trustworthy.
- Legitimacy refers to whether the research process is perceived as fair and ethical by end-users.

A determination of relevance will clearly depend on the perspective and interests of a given user. Credibility refers to technical aspects of sound science, typically determined in a disciplinary context, although there is growing attention to inter-disciplinary determinations of credibility (Belcher *et al.* 2016). Legitimacy deals with the socio-political features of knowledge production and products. In many cases, knowledge users lack the necessary information or capacity to evaluate the credibility of research-based knowledge, so they tend to assess whether the researchers are trustworthy and the research process fair and likely to represent their interests. That is, legitimacy, at least in part, is a proxy measure of credibility. Furthermore, there are trade-offs and complementarities between these attributes that, in some cases, can make it difficult to differentiate them (Cash *et al.* 2003; Sarkki *et al.* 2014; van der Hel and Biermann 2017). For instance, judgments and perceptions of research credibility can be affected when stakeholders' perceptions of legitimacy are negative, or if the perception of legitimacy is highly positive and a strong sense of ownership is developed during the research process, stakeholders may underestimate technical research limitations. Perceptions of relevance, legitimacy, and credibility clearly differ among stakeholders and across cultural contexts depending on scientific literacy, interests, and personal views (van der Hel and Biermann 2017).

We begin by discussing several influential models of the knowledge-policy interface. We then provide a brief overview of the case study and present our methods for data collection and analysis. The results are presented in three subsections: 1. policy-making pathways, as envisioned by researchers and the actual pathway leading to a policy change in our case study; 2. stakeholder perceptions about aspects of knowledge and its use in decision-making; and 3. an analysis of the key attributes of scientific knowledge according to the stakeholders' perspective. The discussion and conclusion sections provide insights to improve design and implementation of research that aims to influence policy. Finally, we offer recommendations based on our case study, but with a broader scope, to improve mechanisms to incorporate scientific knowledge in policy-making more generally.

2. Knowledge-policy models

Two different perspectives can be applied to the study of policy processes. The first perspective refers to the study of 'knowledge in policy process' (Nowlin 2011: 41) and the second to 'the knowledge *of* the policy process' (41). Knowledge of the policy process refers to understanding how policy processes take place and why. Explanatory theories to understand policy processes have been extensively analysed in the literature (Sabatier 2007; Nowlin 2011; Petridou 2014). See Nowlin (2011) and Petridou (2014) for a comprehensive overview of the state of the art of policy theories.

In this article, we apply 'knowledge in policy process' perspective, with a focus on elucidating the ways in which knowledge is used in policy-making and the purposes of the use of such knowledge (Weiss 1999).

Knowledge-policy models have been used predominantly to analyse the application of scientific knowledge in health-policy processes (Trostle *et al.* 1999; Almeida and Báscolo 2006). However, with the exception of the work of the Oversees Development

Institute (ODI) (Jones *et al.* 2008, 2012; Jones, 2009) and a few others (i.e., Cáceres *et al.* 2016; Siyanbola *et al.* 2016), these models have not been used to analyse knowledge-policy interactions related to sustainable development in the Global South. Empirical research in the Global North that focused on the science-policy interface has been useful to depict common barriers inhibiting the use of scientific knowledge in policy-making (e.g., time frames, access to scientific evidence, lack of relevance, unidirectional communication, research literacy, etc.), as well as facilitating conditions for knowledge uptake (e.g., collaboration among researchers and policy-makers, relationships, facilitation skills, etc.) (Oliver *et al.* 2014; Andermann *et al.* 2016).

However, contextual factors unique to the Global South play an important role in how scientific knowledge is perceived and accepted, and how policy processes transpire. Furthermore, the trend towards participatory processes and away from purely technocratic policy-making deserves additional consideration. Empirical studies in the Global South, where knowledge–policy interactions are often immersed in complex, dynamic, and unpredictable socio-political contexts, can provide insights about the application of different knowledge-policy paradigms, the role of different types of knowledge in policy-making, and the role of different stakeholders (Jones 2009).

Knowledge in policy models combines social and public management theories. Weiss (1999) and Funtowicz (2006) each developed typologies of the ways knowledge is used in policy-making (see Weiss 1999 and Funtowicz 2006 for a complete description of the typologies). These typologies share many characteristics and complement one another. For instance, the *Knowledge-driven* model of Weiss (1999) and the *Technocratic* model of Funtowicz (2006) assume that new knowledge is inherently valuable for policy, and that policy is mainly driven by science. Other models recognize that scientific knowledge is uncertain, and for this reason policy-making requires other sources of knowledge and input from stakeholders. Funtowicz's (2006) model of *Science and Policy* places science within a political context in which knowledge is considered valuable if it supports a decision-makers' predetermined position (Weiss 1999). In Weiss' *Enlightenment* model, concepts and theories gain popularity and strength which thereby shift people's thinking and actions over time. This aligns with Funtowicz's model of *Extended Participation* where public dialogue is preferred over scientific knowledge (Valente *et al.* 2015).

Jones (2009) draws on Weiss (1999) and Funtowicz's (2006) knowledge-policy typologies, and provides a synthesis of concepts, key aspects, and analysis of the links between knowledge and policy in development to propose three knowledge-policy models.

Jones' (2009) first model is the *Rational* approach. Described as a linear process where it is assumed that knowledge is good, and if available, knowledge will be used to inform and guide policy (Weiss 1999; Jones 2009). This approach also resonates with the main idea of 'science drives policy' proposed by Funtowicz (2006) in his *Technocratic* and *Precautionary* models.

The second model is the *Pluralism and Opportunism* approach. According to Jones (2009), this approach challenges the rationality of the policy process. It suggests that policy-making proceeds as a linear problem-solving enterprise—as in the *Rational* approach—but that it involves practical decisions taken in uncertainty. The flow of knowledge into policy is not taken as a given; it is opportunistic and depends on the efforts of various actors (Jones 2009).

The third model is the *Politics and Legitimization* approach, which is based on the idea that power permeates during the knowledge process, 'from generation to uptake' (Jones 2009: 5). This approach is related to the *Enlightenment* or *Diffusion* model in which 'both research and policy-making take place alongside other social processes' (Trostle *et al.* 1999: 104) and 'cumulative research shapes concepts and perspectives influencing policy' (Bowen and Zwi 2005: 602) while knowledge is understood beyond scientific research by taking into account 'politics and interests' (602; Weiss 1999). This approach can also be related to the model of *Framing* and the model of *Extended Participation* proposed by Funtowicz (2006). In this model, scientific knowledge accumulates and gradually informs actions (Jones, 2009).

These three knowledge-policy models proposed by Jones (2009) provide a comprehensive summary and integration of the key aspects of the interactions between knowledge and policy discussed in the literature by other authors. Based on these models, we define three main guiding questions that serve as an analytical framework to structure the results section (Table 1).

We use this framework to examine how knowledge was used in decision-making in our case study, and investigate how scientific knowledge is perceived and valued by policy-makers and other key stakeholders, whose knowledge is perceived to be important, what knowledge is taken into account, and the reasons/circumstances under which knowledge is deemed valuable. The questions in the framework are used to guide our analysis.

3. Case study and methodological approach

3.1 Case study description

The Brazil Nut Project (BNP), conducted by the Center for International Forestry Research (CIFOR) in the Department of Madre de Dios, Amazon Region of Peru, between 2012 and 2015, aimed to provide scientific knowledge about the impact of timber extraction on Brazil nut production in Brazil nut concessions to advise and facilitate multi-use forest management. Brazil nuts are one of the most economically valuable non-timber forest products harvested in the Amazon region of Peru, Bolivia, and Brazil, providing a key source of livelihoods for smallholders and their families. In addition, it is regarded as a keystone species for its role in linking sustainable development and conservation practices. The extraction of Brazil nut trees is illegal in the region, but other timber species can be harvested in Brazil nut concessions. The BNP found that when logging intensities are kept below one to two trees per hectare and at least 100 metres from a Brazil nut tree, there is not a statistically significant impact on the production of Brazil nuts (Rockwell *et al.* 2015). Researchers made this information available to policy-makers with the intent to inform the national forest management guidelines.

The commercial use of forest resources (timber and non-timber products) in Peru requires a harvesting/extraction management plan. Formerly, these management plans were approved by the National Institute of Natural Resources (INRENA in Spanish), part of the Ministry of Agriculture (Cossío *et al.* 2014). However, under the decentralization law approved in 2002, functions related to the environment and forest management were transferred to regional governments. In practice, the process of decentralization has occurred differently in each region and administrative unit. The transfer of forest management functions from the central government to the regional government in the Department of Madre de Dios was finalized in 2010 (Cossío *et al.* 2014). Forest management responsibilities were distributed among regional and national

Table 1. Analytical framework to understand the link between scientific research and policy-making

Knowledge-policy approach	Rational	Pluralism-opportunistic	Politics and Legitimization
How is scientific knowledge used in policy-making?	Scientific knowledge is good so it is assumed that it will be used to make decisions	Scientific knowledge is useful if it supports a political gain	Scientific knowledge is used in conjunction with other knowledge (experiential knowledge) to make decisions
Whose knowledge/input is taken into account in policy-making?	Decisions are made by policy-makers using research-based knowledge	Research-based knowledge is used if it serves a political interest (purpose)	Decision-making is influenced by politics and actors' interests, so the process includes input from different sources and actors
What attributes of scientific knowledge are important?	Research sources and the information provided are credible (credibility)	Research provides evidence to support a predetermined decision (relevance, convenience, practicality)	Research is aligned with social processes and contributes to a knowledge base through a legitimate process (legitimacy)

organizations and other actors. The elaboration, approval, and implementation of forest management plans, for instance, required the participation of several government offices from the central and regional level as well as input from non-government actors.

Although regional governments are responsible for most functions, implementation has been limited by a lack of financial resources and personnel (Monterroso *et al.* 2017). Non-governmental organizations (NGOs) have stepped in to fill gaps, providing advice and training to concessionaires in topics related to forestry legislation and more practical issues such as the elaboration of the management plans (Cossío *et al.* 2014). Despite the limitations of the regional government to carry out its functions, decentralization has created opportunities for dialogue and coordination. For instance, space was created for multi-stakeholder coordination in environmental topics at the national and subnational level through the National Environmental Commission as well as environmental commissions at the regional and local levels. Environmental commissions include public and private-sector representatives and civil society. Although the influence of these commissions has been limited in practice, in some cases they have created opportunities for multiple stakeholders to provide technical and institutional input to decisions over land use (Kowler *et al.* 2016).

The Law of Prior Consultation of Indigenous Peoples (Decree No. 29785), which passed in 2011, also created new opportunities for stakeholder participation. According to this law, indigenous peoples should be consulted on any administrative and legislative action and on any development plan or program that could affect their rights (Monterroso *et al.* 2017). The first consultation process was conducted over 2011 to 2015 for the review of the new forest law. This process included the participation of representatives of diverse government agencies, indigenous organizations, universities, research centres, professional organizations, and other representatives of civil society (Monterroso *et al.* 2017).

3.2 Methods

This study was conducted as part of an outcome evaluation of the BNP (Ramirez and Belcher, *in press*). This included:

i. *Documenting the Brazil Nut Project theory of change following Belcher et al. (2017)*. Documentation took place in a workshop setting with the lead researcher from the BNP. A theory of change (ToC) is a model of the main project activities, products, and actors in the system in which the project was situated. A ToC hypothesizes how various actors will use and be influenced by the project activities and outputs and by interactions with other actors, and how this process will result in changes in the science, policy, and practice realms. The BNP ToC is depicted in graphic form as a series of stages in a hypothetical change process (Fig. 1A), supplemented by a narrative description (Table 2) (for more information see Ramirez and Belcher, *in press*).

ii. *Data collection*. Data were collected in two ways. First, we reviewed project documents, meeting reports, government documents, and published material to investigate how the BNP was implemented and how BNP outputs were used. Second, we conducted individual interviews with 24 representatives of various actor groups (including national and regional government, NGOs, Brazil nut producers/concessionnaires, leaders of Brazil nut concessionaire associations, *regentes* (forestry specialists), and researchers identified in the ToC to assess their perspectives on the general policy process, the role of knowledge in the process, and specifically on the role of knowledge produced by the BNP. These actor groups are also referred to as 'stakeholders' throughout the article.

iii. *Data analysis*

Policy change pathways

The BNP ToC (Fig. 1A) documents the pathway through which the BNP researchers expected their findings would reach policy-makers (and other users). Based on the document reviews and interviews, we identified the key actors and events involved in the drafting, modification, and final approval of the management guidelines. Interview participants were asked to identify actors that were involved and that should have been involved in the Brazil nut policy-making process. Additionally, documents related to the Brazil nut policy-making process were analysed looking for specific content to identify actors involved in the policy-making process. We used this information to define the actual pathways that led to the final version of the management guidelines (Fig. 1B). As a central topic raised in the interviews, 'policy-making' was referred and explained to participants as the process of designing, drafting, or/and implementing regulations regarding timber extraction in Brazil nut concessions.

Perceptions on the use of scientific knowledge in policy

A deductive analysis was performed to identify and compare stakeholder perceptions about: key players in the Brazil nut policy-

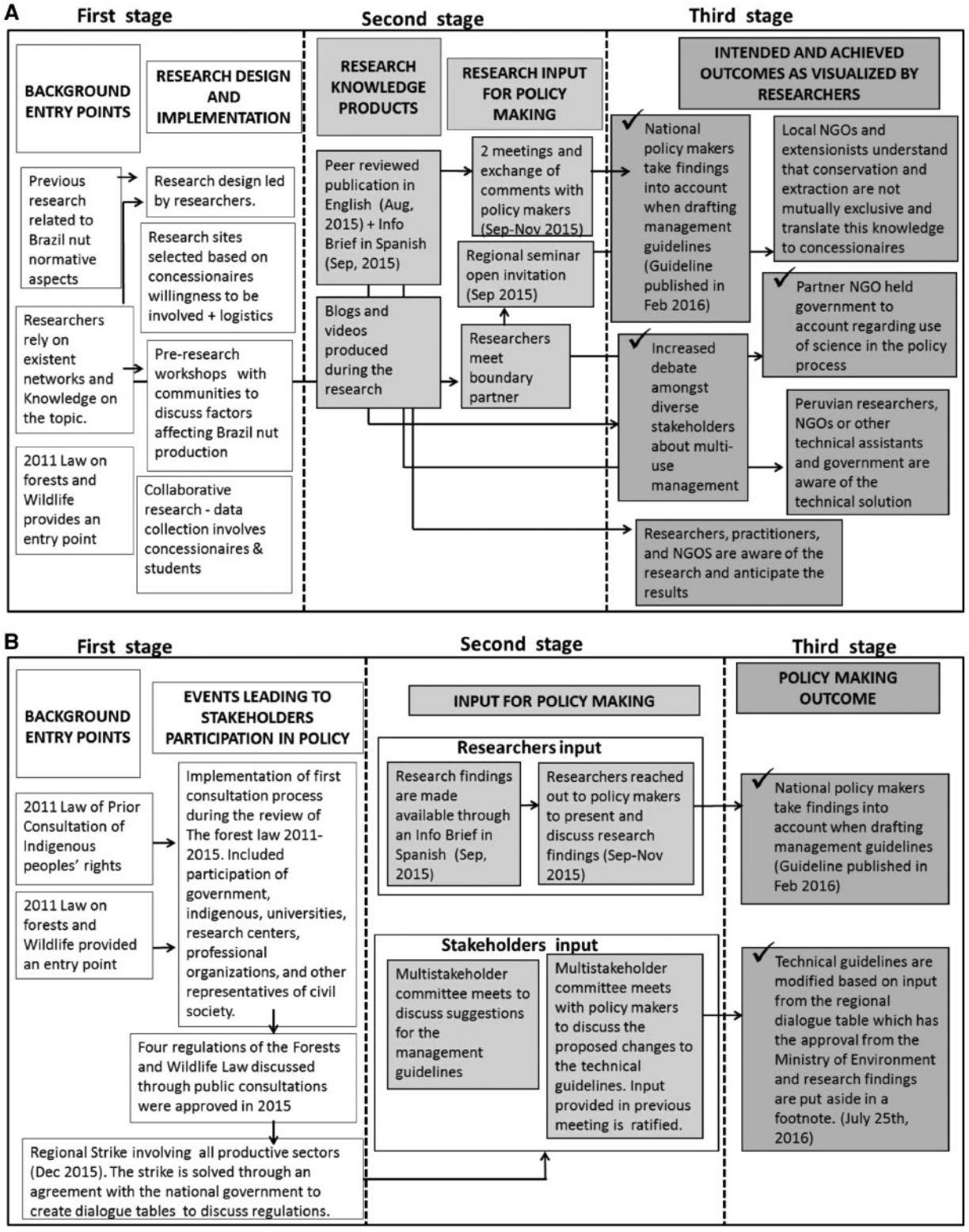

Figure 1. Policy pathway as hypothesized by the BNP researchers (A), and actual policy pathway as reconstructed from interviews and document review (B). √ indicates outcome achieved.

making and implementation processes; what knowledge was influential and where it came from; what factors influenced decision-making; and the value of scientific knowledge in decision-making. The semi-structured interviews included specific questions on these issues, and allowed for unstructured discussion which also led to remarks on these issues.

The deductive analysis was complemented with an inductive analysis conducted in NVivo with preliminary open coding followed

Table 2. Hypothesized and actual policy pathways to inform policy

	Policy pathway as hypothesized by the BNP researchers	Actual policy pathway as reconstructed from interviews and document review
Stage 1: Research entry points, research design and implementation, knowledge products, and events leading to stakeholder participation in the policy process	• Problem identification and research design draw on researchers' previous experience in the area • Researchers' pre-existing networks • The timing of drafting guidelines for the Law of Forest and Wildlife provided a window of opportunity for scientific input • Brazil nut concessionaires participate in project meetings at the beginning of the project and after data collection sessions • Final results are presented in an open forum held in the region with the participation of diverse stakeholders • Knowledge products included a peer-reviewed publication in English, blogs and videos in English and Spanish, and an info brief in Spanish	• 2011 Law on Forests and Wildlife and Law of Prior Consultation of Indigenous Peoples create the need to develop management guidelines and discuss forest regulation through public consultation • First public consultation process in Peru related to natural resource management created unprecedented opportunities for stakeholder participation in policy processes • Regional strike from 23 November until 4 December of 2015, involving various economic sectors (mining, logging, Brazil nut producers, and transportation) • To end the strike, the government established dialogue boards where each economic sector and government representatives would discuss demands and find agreement
Stage 2: Research and stakeholders' input for policy-making	• Scientific findings presented and discussed with policy-makers	• Scientific findings presented and discussed with policy-makers • With the creation of the dialogue tables (after the strike), regional stakeholders have the opportunity to refute the guidelines and provide input for their modification
Stage 3: Intended and achieved policy outcomes	• Outcomes associated with the policy pathway were either partially or completely achieved (Figure 1a) • First version of the management guidelines published in February 2016 included scientific evidence provided by researcher	• Scientific input was initially used to inform the management guidelines; however, the discussions with stakeholders led to the revision of the management guidelines and a modified version, where scientific information was used as a footnote, which was published in July 2016

by axial coding (Bryman *et al.* 2009). Thirty-four codes were defined in the open coding process. Axial coding led to the identification of categories related to knowledge-policy links and aspects influencing policy-making. Some of the key themes that emerged from the analysis included decentralization, stakeholder engagement in the research process, and stakeholder participation in policy-making.

4. Results and analysis

4.1 Policy change pathways

The comparison of the key elements and stages of the policy pathway in the original (hypothetical) project ToC (Fig. 1A) with the actual policy pathway (Fig. 1B) reveals instructive differences, which are summarized in Table 2.

The BNP researchers expected that their research would influence policy in a way closely aligned with the *Rational* model of policy-making (Table 2). National-level policy-makers were viewed as key actors with power to make decisions. As illustrated in Fig. 1A, some of the expected research outcomes involved non-governmental actors (notably forestry consultants and NGOs); however, priority was given to communicating research findings to national policy-makers and engaging with them to inform the development of the management guidelines.

Some open meetings were used to share research findings with regional stakeholders. These meetings included a presentation of preliminary results organized by the researchers, which were held in the region as well as incorporated into a seminar organized by a local university. Both events were open to anyone interested in Brazil nut management aspects, such as environmental NGOs, regional government, concessionaires, and *regentes*. According to our interviews, these meetings were insufficient to share the research results and many key stakeholders were not exposed to the research and/or did not understand the findings.

In this first round, the *Rational* model of policy-making seemed to hold as policy-makers were receptive and willing to use scientific evidence to draft the management guidelines. In fact, the draft management guidelines used and cited a specific recommendation provided by the BNP. However, political and external factors quickly came into play. Notably, the law of Prior Consultation of Indigenous Peoples was implemented in response to incidents related to protests organized by indigenous groups to claim their rights regarding the use of natural resources (e.g., El Baguazo, see Monterroso *et al.* 2017 for details). More generally, the forest law consultation process carried out between 2011 and 2015 not only promoted public participation but also increased government awareness of resource users' consultation rights. Another significant event was a multi-sector regional strike (that included Brazil nut producers) that took place in Puerto Maldonado between 23 November and 24 December 2015. The national government responded by creating regional dialogue boards with representatives of the strikers and the relevant Ministries. One of those dialogue boards concerned

Table 3. The research problem as perceived by stakeholders

NGOs	Government	Associations & Concessionaires	Researchers/field assistants	Regentes
• Land tenure issues • Regulation complexity • Third party timbers	• Ensuring that timber extraction in Brazil nut concessions is sustainable • Land tenure issues • Regulation complexity • Third party timbers	• Land tenure issues • Regulation complexity • Third party timbers	• Lack of ecological information • Controlling timber extraction	• Land tenure issues • Regulation complexity • Third party timbers

Table 4. How has scientific information influenced or contributed to your work?

NGOs	Government	Associations & Concessionaires	Researchers/Field Assistants	Regentes
• As a reference	• As a reference • As a starting point	• Results do not provide a concrete solution and action • Concessionaire obtained information about the concession, stipend, skills to organize documentation	• As a preliminary work	• Scientific information has not had any influence

Brazil nut management and involved the Federation of Brazil Nut Producers of Madre de Dios (FEPROCAMD), loggers, regional government, NGOs, *regentes*, and national government representatives. Some of the participants in the Brazil nut dialogue board also participated in further discussions about the Brazil nut management guidelines. Specifically, representatives from the Brazil Nut Federation, regional government, NGOs, and *regentes* were involved in discussion and review of the draft Brazil nut management guidelines, and suggested modifications to the national forestry authority. Informants representing these actor groups that participated in this dialogue board were interviewed as part of the BNP evaluation.

4.2 Stakeholders' perceptions on knowledge and policy-making

This section examines stakeholders' perceptions regarding research needs, knowledge use, and sources in decision-making, key stakeholders in policy and management, and main factors influencing decision-making in the preparation of the new guidelines. The result tables report stakeholders' perceptions without any particular order of significance or frequency. Answering these questions provides insights into how stakeholders validate and use scientific knowledge in policy-making.

4.2.1 Using scientific knowledge in Brazil nut Forest management guidelines

Perceptions on research needs and relevance of the research question

Two key challenges mentioned by almost all stakeholder groups (excluding researchers) are: 1) controlling timber extraction by third party timber harvesters and illegal timber harvesters; and 2) conforming with complex guidelines (Table 3). The BNP research question identified timber extraction as one of the problems, but the research question and solution provided by the project focused primarily on estimating a limit on timber harvests to avoid negatively impacting Brazil nut production. The research did not focus on broader questions around illegal or excessive logging. In that sense, from the stakeholder's point of view, the research question did not address the key (to them) problem. Instead, from the perspective of resource users and *regentes*, the project led to more restrictions on Brazil Nut concessionaires as illustrated in the following quotation: 'As the guidelines were established, if seed trees had to be left [untouched] and it is not permitted to log at least 50 to 100 metres apart from a Brazil nut tree, practically timber cannot be extracted from the concession' (Reg1).

Some of the research needs from the government and researchers' perspective—the lack of ecological information about Brazil nut regeneration and the urgency of ensuring that both timber extraction and Brazil nut production are sustainable—align with the BNP research question. Respondents from these stakeholder groups indicated a greater appreciation of the research and its findings. However, according to other stakeholders, the BNP research was not considered highly relevant.

Perceptions about the influence of BNP research on management of Brazil nut concessions

Stakeholders' expressed diverse perceptions about the usefulness (contribution or influence) of the research (Table 4). Most of the respondents considered the research as a good reference and starting point to initiate the conversation, but was insufficient on its own for decision-making.

These perceptions seem to be related to stakeholders' observations about aspects of research design, such as sample size and sampling period as illustrated in the following quotation:

> It is required to have more solid information over years of study, bigger monitoring zones, and different degrees of intervention [. . .] A two-year study may only cover one cycle of the individual and it requires at least eight years of research to see where in the cycle that sampling fell. [. . .] It [the research] is good as a starting point, but by no means conclusive' (Professional researcher).

This presents an interesting challenge for researchers. While they may feel that the design is scientifically sound and has been

validated by a peer-review process, some stakeholders question the scientific credibility. Furthermore, these perceptions on research credibility are often mixed with legitimacy concerns. The following quotation conveys these sentiments:

> we don't know what the final result is. I don't know which result it reached, what the final conclusion of the study is. However, even the national government assumed it as a valid study, but it hasn't been proved scientifically, you can't take this as something valid. And the sample they chose is not appropriate to support [the study]; They were [only] five concessions and that is not enough to say "yes, the variation is [due to this]" because in each province the soil and production are different. For us, the sample isn't representative... that study isn't validated. How can it be taken as a reference if we made observations and [said] we didn't agree? (Asso2).

According to the interviewee, this means that comments on preliminary research findings were made by the association of concessionaires, but they were not taken into account by the researchers. The indication that the final results were not shared with the concessionaire associations and that the observations made by them in the initial meetings were not taken into account can be interpreted as a matter of legitimacy. This suggests that a key stakeholder (the Brazil nut association) was not fully taken into account in all the stages of the research, and as suggested by the interviewee, aspects of research design such as the sample size affect research credibility.

Perceptions about the value of scientific knowledge in general and particularly in policy-making vary among stakeholders depending on their background, training, and exposure to research and academia. As indicated in Table 4, however, participants rarely rely on scientific research for decision-making.

There is a clear discrepancy between researchers' and other stakeholders' perceptions of the main challenge for management. The researchers saw the problem as a knowledge deficit and conducted the research to fill the knowledge gap. Yet, Brazil nut concessionaires, NGOs, and even government stakeholders perceive the main problem to be the lack of capacity on the part of government and users to control excessive and illegal timber extraction, lack of financial support, and challenges due to environmental issues (e.g., climate change) in some cases. The value of research from a non-researcher stakeholder perspective is based mainly on whether or not the knowledge produced helps to address practical issues that respond to their interests and needs. The divergence between what project researchers and other stakeholders perceived as the main challenges for sustainable forest management poses a fundamental challenge for building consensus about the relevance of the findings and translating those findings into usable knowledge for policy-making.

4.2.2 Whose knowledge is used

Perceptions on who are the key actors in Brazil nut management and their influence in policy-making

Stakeholders expressed different perceptions about who the key actors are, about their role in decision-making, and about the kind of knowledge they deem important compared to the researchers and depicted in the original ToC (Fig. 1A). In the BNP ToC, policy-makers at the national level and researchers (researcher institutes and academia) were identified as the key players in Brazil nut management decisions and policy-making. National policy-makers were not only identified as key actors by other stakeholder groups, but they also identified regional government, NGOs, concessionaires, and *regentes*, among others (Table 5).

The lack of participation by these other stakeholders in discussion of the research findings and their use in drafting the Brazil nut management guidelines influenced perceptions of the project's legitimacy. For instance, in the following quotation, an informant that participated in the meetings where concessionaires questioned the management guidelines indicates that concessionaires' interests and perspectives were not adequately represented in the validation of the research findings.

> Maybe the mistake was to publish the study first without telling them. We talked to researchers and told them: "if you normally work with [Brazil nut producers], you have to show your results, to explain to them first. Then you can also get some recommendations from them". But they didn't do it. That's another lesson to be learnt. If you do research, you have to tell them first and then you can publish it, including their contributions as notes' (NGO5).

What knowledge is perceived as important and where do stakeholders get the knowledge they need to make decisions

According to the interviews, stakeholders rely on diverse kinds and sources of knowledge for making decisions (Table 6). Many stakeholder groups (except professional researchers and concessionaires) indicated that they use knowledge and information produced by NGOs relating to the delimitation of concessions, concessions mapping, forest inventory, and the dissemination of regulations and training. NGOs, government representatives, and researchers also reported using information provided by research organizations. Concessionaires reported that they rely mainly on information provided by the Federation of Concessionaires and from their own and other concessionaires' experience. Participants from the National Forestry Authority and one of the researchers interviewed mentioned knowledge gathered in working committees and other meetings as important for decision-making. All stakeholders recognized that knowledge used in decision-making may come from a variety of sources.

What factors influence and contribute to decision-making

There was broad agreement among stakeholders that political and economic considerations have a strong influence on decision-making. Government changes, international agreements, and the priorities of the government in power shape policy regarding the management of the Brazil nut concessions (Table 7). Thus, knowledge that is relevant to these economic and political interests and made available in a timely way may have a stronger influence in decision-making.

Interestingly, one representative from the concessionaires group mentioned that direct interactions with researchers have had a profound impact on her thinking about the forest and the management of Brazil nut concessions. This attests to the effects that trust-building and genuine engagement, which are crucial aspects of legitimacy, can have in influencing change and increasing the perceived value of research for making decisions.

Table 5. Perceptions of stakeholders holding a key role in decision-making

NGOs	Government	Associations & Concessionaires	Researchers/field assistants	Regentes
• National Forestry Authority • Regional Forestry Authority • Researchers • Concessionaires and their families • Ministries • Private industry • Regentes • NGOs • Loggers and traders	• National Forestry Authority • Regional Forestry Authority • Researchers • NGOs • Concessionaire associations • Civil society	• National Forestry Authority • Regional Forestry Authority • Researchers • NGOs • Concessionaires	• National Forestry Authority • Regional Forestry Authority • Researchers	• National Forestry Authority • Regional Forestry Authority • Concessionaires • Concessionaire associations • Users • Traders • Regentes • Some NGOs

Table 6. Where do stakeholders source knowledge they need to make decisions?

NGOs	Government	Associations & Concessionaires	Researchers/field assistants	Regentes
• NGOs • National Forestry Authority • Research institutes (national and international)	• Research institutes (mainly international) • NGOs • Working committees, meetings	• There is not information • Federation of Concessionaires • Producer/concessionaire experiences	• Research institutes (national and international) • Technical discussion tables	• NGOs working in the region • University training • Field data

Table 7. What are the factors that influence and contribute to decision-making?

NGOs	Government	Associations & Concessionaires	Researchers/Field Assistants	Regentes
• The organization's strategic plan is shaped by regional factors like government and the government in power	• International agreements • Change of government • Regional discussion tables	• Person-to-person interactions	• Most research is aligned with budget programs and the national policy level	• The market • International agreements with the United States

Opinions about what factors influence decision-making regarding Brazil nut management and policy are diverse among stakeholders, and these different approaches to decision-making imply the use and validation of different knowledge sources. Government participants and NGOs recognize not only the role of policy-makers and researchers, but also of concessionaires associations, NGOs, and civil society in decision-making. Some of the NGO respondents mentioned the role of the concessionaires' families, *regentes*, and Brazil nut traders (buyers) as well as loggers in Brazil nut management. However, the knowledge NGOs use comes mainly from the same NGOs, research centres, and the National Forestry Authority. Interviewees from the Association of Concessionaires did not identify researchers or academic actors as having a role in Brazil nut policy-making, and instead acknowledged their own role as well as the role of the NGOs and national and regional governments in Brazil nut management. The knowledge they use comes predominantly from the government and *regentes* working for them, as well as learning from experience. Similarly, *regentes* identified the role of national and regional authorities, NGOs, concessionaire associations, as well as traders and themselves as key players in Brazil nut policy-making. *Regentes'* main knowledge sources come from fieldwork, satellite images and aerial photographs, and training provided by universities.

These perceptions help establish expectations about who should take part in the decision-making process and what knowledge is used. In that sense, while researchers' identification of key players follows a *Rational* model, other actors seem to expect a more participative approach that resembles the *Political and Legitimization* model. The revision process, in which policy-makers used stakeholders' input to draft a new version of the management guidelines as a reaction to the stakeholders' rejection of the initial guidelines, essentially follows the *Political and Legitimization* model. Policy-makers not only validated the research findings, but also incorporated input provided by stakeholders.

In the current context of decentralization and stakeholder participation in environmental decision-making, with support from the 2011 Law of Prior Consultation of Indigenous Peoples, as well as the Dialogue Board created after the strike in 2015, stakeholders' input was particularly influential in the drafting of the revised version of the management guidelines. Policy-makers incorporated stakeholder input in the new version of the guidelines to legitimize the guidelines and avoid potential conflict. Input was provided through two proposals prepared by regional stakeholders (i.e., forestry consultants, resource users, regional government, and NGOs). However, whether these proposals represented the interests of all concessionaires is unclear. As indicated in the following quotation, some participants suggested that the research findings were contested by influential stakeholders because the management guidelines conflicted with their economic interests:

> I think it wasn't really about the document but about finding an excuse to modify the guidelines in their favor. Because considering the division in 20 parts, the area remaining was much more reduced, then the volume [permitted] was too little and their argument was that it was not enough to manage and provide returns. [. . .] there is a public person [. . .] who was especially interested in modifying this. He's a concessionaire and a person who has always been involved in the forestry sector' (Gov2).

Interestingly, one of the proposals to modify the guidelines referred to an old academic reference to justify a revision of the guidelines. This suggests that stakeholders—that are not familiar with scientific knowledge or do not normally rely on scientific information to make decisions—may be willing to acknowledge scientific research when the findings serve their cause. Information from the interviews suggests policy-makers' willingness to adopt a more consensual approach in the drafting of the management guidelines was related to a need to avoid conflict with stakeholders, particularly in a moment where the government was finalizing its mandate.

4.3 Key attributes of scientific knowledge: the stakeholders' perspective

Specific knowledge attributes can be associated with each of the knowledge-policy models outlined in our framework. In the *Rational* model, credibility and relevance are the key attributes to validate scientific knowledge (Table 1). In our case study, policy-makers initially perceived that the research findings were credible and useful (Table 2), and thus incorporated them in the draft management guidelines. This acceptance of the scientific knowledge by policy-makers is explained in part by the good relationship developed between the research organization and the National Forestry Authority. Innvaer *et al.* (2002) and Jones *et al.* (2008) observed that in developing countries, trust of research findings and recommendations is often associated with personal ties and trust between researchers and policy-makers and stakeholders, which Cash *et al.* (2003), Belcher *et al.* (2016), and others conceptualize as reflections of legitimacy. Such relationships may be a crucial factor for the use of research in policy.

The use of the BNP findings in the draft management guidelines indicates that the *Rational* approach was effective. However, once regional stakeholders questioned the management guidelines and challenged aspects of the research design, policy-makers shifted their approach. The stakeholders' opportunity to demand revisions of the guidelines in combination with the government representatives' desire to avoid conflict and achieve consensus shifted the policy-making process from a primary emphasis on research-based knowledge (the *Rational* model) to one in which decisions were influenced by politics and actors' interests, with input from different sources and actors (*Politics and Legitimization* model). Although policy-makers reiterated the credibility of the research, they also acknowledge that their priority was to avoid conflict with stakeholders and reach agreement.

The shift from the *Rational* model to the *Politics and Legitimization* model aligns with Funtowicz's (2006) argument about how models of science-policy interactions can co-occur and complement each other or be in conflict. Similarly, Valente *et al.* (2015) found characteristics of different science-policy models in the responses given by research participants, suggesting that stakeholders' positions about knowledge in policy may change through time. In our case study, the interview analysis indicates that policy-makers made an effort to find a balance between stakeholder claims, scientific knowledge available, and the political setting. Although policy-makers modified the management guidelines and removed the specific BNP recommendation for the timber harvest limit from the main guidelines, they still included that recommendation in a footnote. Thus, it is not only the convenience or practicality of the research findings which influence their use in drafting policy guidelines, but also the need to legitimize the process and guarantee the validation of the management guidelines by stakeholders.

5. Discussion and conclusions

The analysis presented here shows that there is not a singular pathway through which research can influence or inform policy, or through which policy is made. Policy-making is a complex process influenced by multiple stakeholders and factors. As demonstrated in our analysis, democratization, aspects of centralization and decentralization, scientific literacy, as well as civil society interests and capacity in decision-making processes influence 'which ideas and whose knowledge is used in the policy processes' (Jones *et al.* 2008: 14). Therefore, in contexts with multiple stakeholder participation in policy processes where stakeholders interpret and value scientific knowledge in diverse ways (Hisschemöller and Midden 1999), it can be challenging to define a unique pathway through which scientific knowledge can inform policy. According to Hisschemöller and Midden (1999), aligning research and policy approaches may be a way to increase stakeholders' validation of scientific-based evidence and the usability of research in decision-making. To increase the usability of scientific evidence in sustainability policy, various authors have discussed the need to integrate both science and policy aspects when defining sustainability indicators (Pülzl and Rametsteiner 2009; Kothari *et al.* 2011). In that sense, Pülzl and Rametsteiner (2009) point out the need to move away from a model of knowledge transfer to adopt a 'transaction model' (743) to span 'the boundary between the scientific and the political domains' (743).

5.1. How is scientific knowledge perceived by stakeholders?

The perception of scientific knowledge varies by stakeholder. In the BNP, relevance was pursued through the timely provision of independent advice in an ongoing policy process, with a focus on sustainable multi-use management of Brazil nut concessions. This aligns with van der Hel and Biermann's (2017) typology of strategies by which science institutions aim to foster perceptions of relevance among actors in sustainability governance. Researchers and policy-makers appreciated the BNP research as important to help advance understanding of Brazil nut ecology and provide insights about the sustainable multi-use management of Brazil nut concessions. However, other actors, such as resource users, *regentes*, and NGOs, did not share the same perceptions of relevance. These stakeholders are more concerned about land tenure security, illegal timber extraction, and climate change, among others. Moreover, at least for resource users, the research recommendation was controversial as it implied reducing timber extraction quotas, which was against their interests. While researchers and policy-makers might not have a particular interest in forest management other than the common good, stakeholders' perceptions of research relevance are shaped by their own interests. In this regard, there is a link to aspects of legitimacy which play a key role in shaping the overall perceptions of scientific knowledge, including whether or not such knowledge is relevant.

Thus, the lack of deliberate consideration of all stakeholder groups' values, interests, and perspectives in defining the research resulted in outputs that are considered to have limited relevance by stakeholders directly involved or dependent on forest resources.

The BNP outcome evaluation (Ramirez and Belcher, *in press*) shows that the project included some key elements to achieve legitimacy, with some level of involvement of resource users and policy-makers and some consideration of resource users' perspectives on factors affecting Brazil nut production. However, the level of engagement seems to have been insufficient to integrate all relevant stakeholders' perspectives.

Regardless of the criticisms on research design aspects (i.e., number of samples, sampling period), the findings suggest that most stakeholders appreciated the value of this kind of research and recognized that the BNP provided interesting methodological innovations and helped address existing knowledge gaps. Informants also recognized that forest management decisions have often been made in the absence of evidence, so the effort by policy-makers to use scientific knowledge to draft the management guidelines indicates an important shift. Weichselgartner and Kasperson (2010) suggest that the use of scientific knowledge by policy-makers in developing countries is often limited to solely informing conversations. Karlsson *et al.* (2007) suggest lower scientific capacity in developing countries limits opportunities to provide scientific advice to policy-makers and create a culture of evidence for policy-making.

Research design observations made by stakeholders also reflect perceptions on the credibility of the scientific knowledge produced. These criticisms on research design were used to justify why scientific recommendations were not fully incorporated in the final draft of the Brazil nut management guidelines.

5.2 How do stakeholders' perceptions influence the policy process?

Power has a crucial role in shaping the knowledge-policy interface (Jones 2009). How perceptions of scientific knowledge by different stakeholders influence the policy process strongly depends on who is included in making decisions. In this case, and in contrast to typical decision processes in the forest management context in Peru, regional stakeholders, resource users (Brazil nut concessionaires), and *regentes* had the power to be heard and have their suggestions included in the management guidelines. This underlines the need for a deep understanding of the power dynamics and interactions among stakeholders. Understanding stakeholders' perspectives, interests, and values is also crucial in order to influence what kind of knowledge is needed, how to produce that knowledge, and how it will be used in policy-making.

5.3 How is scientific knowledge used in decision-making in a policy process?

We found that the *Rational* model followed in the original BNP ToC did not hold in the context of the decentralization of forest management responsibilities and increasing stakeholder

participation in natural resource management in Peru. The current political transition towards a more democratized system led to an approach more aligned with the *Politics and Legitimization* model.

This illustrates the complexity and constantly evolving nature of policy processes. Again, the complex nature of sustainability problems challenges the known policy pathways, requiring a more flexible and adaptive approach for knowledge to be produced and new ways of making sense of it for effective policy-making (Hellström and Ikäheimo 2017). This should include, as suggested by Hisschemöller and Midden (1999), 'that researchers and policy makers question their own assumptions on the public's role' (17).

The *Politics and Legitimization* model is aligned with existing literature on environmental governance of natural resources at local and regional levels (Armitage *et al.* 2015; de Vente *et al.* 2016) as well as sustainability science (Cash *et al.* 2003; Lang *et al.* 2012; Clark *et al.* 2016), which highlights the integration of different kinds of knowledge (e.g., scientific, local, governmental) as one of the factors for effective environmental governance. Regardless of the fundamental role of scientific knowledge in informing decision-making, it is clear that scientific knowledge is not sufficient to deal with complex environmental problems which also require engagement with power issues, stakeholders' interests, politics (Lejano and Ingram 2009; Armitage *et al.* 2015), socio-economic and political factors, and characteristics of the cultural environment influencing the policy processes.

Despite the numerous studies that emphasize the importance of stakeholder engagement as a crucial aspect in decision-making and effective implementation of environmental policies and governance (Reed 2008; Armitage *et al.* 2015; de Vente *et al.* 2016), participatory policy-making comes with its own challenges. Particularly in contexts such as Peru, where participation of stakeholders in policy-making is in its infancy and corruption and elite interests influence resource use policies (Kowler *et al.* 2016). Decision-making at the local level is affected by the capacity of the decision-making body (i.e., rule of law, government effectiveness), local power relations and corruption, the incentive structure for resource management, and general attitudes toward the environment (Ribot and Larson 2005; Karlsson *et al.* 2007). According to Karlsson *et al.* (2007), these factors together with income are good predictors of scientific productivity in environmental sciences and research literacy. Thus, although decision-making and research processes aiming to inform policy should ideally engage stakeholders in the process (Innvaer *et al.* 2002; Reed 2008), and regardless of the efforts made by some researchers to do that, limited research literacy, corruption, power imbalances, and lack of institutional and social capacity affect the overall quality of stakeholders' participation in policy processes. As pointed out by Jones *et al.* (2009), participation and priority toward social processes do not always result in better use of evidence or quality of dialogue.

Silver and Campbell (2005) found that although resource users' participation in research and policy-making is perceived by stakeholders as an opportunity to speak up, offer their knowledge, communicate with government, and contribute to the conservation of resources, stakeholders' participation may negatively affect the quality of the policy outcomes. This may happen when, in an effort to legitimize the policy process, stakeholders' input is accepted without questioning stakeholders' own vested interests and biases. Furthermore, if stakeholders' input is not used, it might harm future initiatives. Accordingly, to improve the opportunities to succeed in achieving the validation of scientific knowledge in decision-making, particularly in scenarios where stakeholder participation is accepted and implemented, research should ideally involve stakeholders at all stages of the research, from project and research question formulation, to data collection, to policy formulation (Silver and Campbell 2005; Reed 2008). This approach to the research process aligns with the *Policy and Legitimization* knowledge-policy model. A note of caution, however, is that stakeholder participation in policy-making is very recent in Peru. The *Politics and Legitimization* approach may be the result of a political moment that can easily change depending on the president and the political party in power. In consequence, exploring multiple knowledge-policy pathways within a research project may be an effective strategy for moving towards more effective evidence-informed policy-making processes in developing countries.

6. Recommendations

Given the complexity of environmental sustainability problems and solutions and the strong influence of context, it is not possible to define blueprints that guarantee effective science-policy interactions for Peru and beyond. Nonetheless, we draw from our findings and analysis to provide recommendations about research design and implementation that may increase the utilization of scientific research in policy-making, particularly in developing countries.

- Using a transdisciplinary research perspective that pays attention to aspects of relevance, credibility, and legitimacy in the design and implementation of research initiatives may help improve overall research effectiveness. This perspective includes having a clear understanding of the policy context and how decisions are made in order to identify key stakeholders and incorporate mechanisms for meaningful engagement during all research stages (see Belcher *et al.* 2016 for design criteria).
- Being alert to changes in policy (e.g., government changes, new policies, civil society claims and movements, etc.) during the implementation of a research project, and flexible to adjust project design and implementation accordingly can help meet new needs and opportunities that such policy changes may impart. In our case study, such a reflexive process might have helped researchers to shift the knowledge-to-policy *Rational* approach to better support the *Political and Legitimization* model adopted at the end by policy-makers.
- Researchers should be aware of the level of scientific literacy in the research context and adjust research design and implementation mechanisms to that context in order to increase the uptake and validation of knowledge. Some mechanisms may include participatory data collection tools, trainings, and creation of discussion fora that facilitate knowledge diffusion and co-production.

Finally, understanding the power dynamics and interactions among stakeholders and their perspectives, interests, and values will help identify research priorities and mechanisms to increase research relevance, credibility, and legitimacy. This may further increase the prospects of scientific knowledge uptake to improve policy-making and ultimately support environmental sustainability.

Supplementary data

Supplementary data is available at *SCIPOL Journal* online.

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